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| **Fiscal Year:** | FY 2017 | **Task Last Updated:** | FY 08/02/2016 |
| **PI Name:** | Oman, Charles M. Ph.D. | | |
| **Project Title:** | Design and Evaluation of Automated Electronic Checklists for Robotics Operations | | |
| **Division Name:** | Human Research | | |
| **Program/Discipline:** | | | |
| **Program/Discipline--Element/Subdiscipline:** | HUMAN RESEARCH--Space Human Factors Engineering | | |
| **Joint Agency Name:** | | **TechPort:** | No |
| **Human Research Program Elements:** | (1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H) | | |
| **Human Research Program Risks:** | (1) **HSIA**:Risk of Adverse Outcomes Due to Inadequate Human Systems Integration Architecture | | |
| **Space Biology Element:** | None | | |
| **Space Biology Cross-Element Discipline:** | None | | |
| **Space Biology Special Category:** | None | | |
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| **Zip Code:** | 02139-4301 | **Congressional District:** | 7 |
| **Comments:** | | | |
| **Project Type:** | Ground | **Solicitation / Funding Source:** | 2014-15 HERO NNJ14ZSA001N-Crew Health (FLAGSHIP & NSBRI) |
| **Start Date:** | 10/01/2015 | **End Date:** | 09/30/2017 |
| **No. of Post Docs:** | 1 | **No. of PhD Degrees:** | 0 |
| **No. of PhD Candidates:** | 0 | **No. of Master' Degrees:** | 1 |
| **No. of Master's Candidates:** | 1 | **No. of Bachelor's Degrees:** | 0 |
| **No. of Bachelor's Candidates:** | 1 | **Monitoring Center:** | NASA JSC |
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| **Flight Program:** | | | |
| **Flight Assignment:** | NOTE: Element change to Human Factors & Behavioral Performance; previously Space Human Factors & Habitability (Ed., 1/19/17) | | |
| **Key Personnel Changes/Previous PI:** | August 2016: No changes | | |
| **COI Name (Institution):** | Liu, Andrew Ph.D. ( Massachusetts Institute of Technology ) | | |
| **Grant/Contract No.:** | NNX15AW35G | | |
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| **Task Description:** | The primary objective of this project is to provide empirical evidence supporting design guidelines for automated electronic checklists for robotics operations. We use International Space Station (ISS) robotic arm operations as our proxy for general space operations and are developing scenarios to test a crew's ability to interact with more system automation than available in current ISS operations.<br>This project has the following two specific aims:<br><br>1. Develop a prototype display for robotics operations that integrates the electronic procedures with the displays for performing robotic tasks. The design process will begin with a hierarchical task analysis approach to drive out functional and information requirements for the display. Additionally, critical system states will be identified using a "Object-Process Methodology," a task modeling approach that extends the task analysis to a computable level. Lessons learned from the development of aviation electronic checklists will also be considered in the design. We will augment our prototype design with the capability for automated execution of procedural steps. This prototype will be built on the MIT (Massachusetts Institute of Technology) ISS robotic workstation simulation that has previously been used in several National Space Biomedical Research Institute (NSBRI) projects.<br><br>2. Perform a human-in-the-loop study that investigates the following questions concerning design choices for the integrated display:<br><br>a. Does the prototype electronic checklist enable the same or better situation awareness during task execution while minimizing mental workload when compared to current practice?<br><br>b. What procedural steps should be allocated to human operators or to the automation for both nominal operations and off-nominal, time-critical operations? How does the reliability of the automation affect the ideal allocation of steps?<br><br>c. Does the use of automated procedural step execution increase or decrease the human operator's information requirements when executing multiple procedures?<br><br>The project results will provide a design method, implementation guidelines, and supporting empirical evidence for designing electronic checklists for other tasks. |
| **Rationale for HRP Directed Research:** | |
| **Research Impact/Earth Benefits:** | Although we are using robotic arm operations on the International Space Station as our study platform, the results of this research could be applied to many Earth-based systems. Aviation, for example, has been a domain that has long used checklists to complete complex procedures safely. However, the use of a checklist does not automatically rule out the possibility of human operator errors. Errors of commission or omission of checklist steps, miscommunication between pilots, stress and time pressure in an emergency situation, among other factors, can lead to mistakes. To mitigate these mistakes, the aviation industry has increased the role of automation in the cockpit, including recent integration of electronic checklists, allowing the computers to do some of the work so that the pilots aren't overloaded and are less likely to make an error. Our study aims to investigate the effect of varying levels of automation on human performance when using electronic checklists and could provide valuable insight not only for future space robotic operations, but also to the aviation industry, and other domains in which the human and automation must work together to accomplish complex procedures. |
| **Task Progress:** | During the first year of this award, we focused our efforts on achieving Specific Aim 1, developing a prototype electronic procedure system with new automated capabilities, into our robotic workstation simulator. First, informed by actual robotic arm procedures conducted on the International Space Station, we defined and developed a set of robotic task scenarios that includes system setup, support of a series of simulated spacewalk activities, and system shutdown. Within these scenarios, the possibility for a variety of failures and associated failure recovery steps were designed and built into the simulation so that we can test responses to non-normal situations. We used tools including Hierarchical Task Analysis (HTA) and Object-Process Methodology (OPM) to break down each task goal into its components and necessary actions and to define system states throughout the flow of the simulated robotic arm operation.<br>Secondly, we used the HTA and OPM analyses to design the computer code that creates the simulated integrated control panel and procedure checklist system. In doing so, we created a new type of human-machine electronic procedure interface that integrates automation and system information into an electronic display. By integrating a functional electronic control panel, procedure, and checklist into our simulator, we created a system that presents information equivalent to two separate systems and laptops that are currently used on the International Space Station during robotic operations. This, in turn, reduces the required number of displays and equipment, an important feature for future space missions that will have strict mass and power constraints. |
| **Bibliography Type:** | Description: (Last Updated: 12/18/2024) |